Research Paper Engineering

Design Optimization using Genetic Algorithm and Validation in Ansys

Durgam Mahesh	Mechanical Engineering Department, Institute of Aeronautical Engineering, Dundigal Village, Quthbillahpur Mandal, Hyderabad, 500043
MD.Ajaz miyan	Mechanical Engineering Department, Institute of Aeronautical Engineering, Dundigal Village, Quthbillahpur Mandal, Hyderabad, 500043
Rajesh Banjare	Mechanical Engineering Department, Institute of Aeronautical Engineering, Dundigal Village, Quthbillahpur Mandal, Hyderabad, 500043
V.Varun nath	Mechanical Engineering Department, Institute of Aeronautical Engineering, Dundigal Village, Quthbillahpur Mandal, Hyderabad, 500043
Mr. N.Ananth	Mechanical Engineering Department, Institute of Aeronautical Engineering, Dundigal Village, Quthbillahpur Mandal, Hyderabad, 500043
Prof. V.V.S.H.Prasad	Mechanical Engineering Department, Institute of Aeronautical Engineering, Dundigal Village, Quthbillahpur Mandal, Hyderabad, 500043

ABSTRACT

This paper studies the minimum weight design of plane and space trusses under failure criteria, The optimization of truss is first performed by using a binary genetic algorithm and continuous genetic algorithm. The objective of the optimization study is to find the optimal truss design. The problem is to determine the minimum value of the weight/cost associated with the truss structure design while a set of stress and displacement constraints are to be satisfied. This work uses a Genetic Algorithm (GA) to solve the integer optimization problem by selection of a number of standard cross sections. The results obtained show how good this technique behaves, even when compared to more specialized and sophisticated optimization methods This paper focuses on the use of a search technique called Genetic Algorithm (GA) to optimize the design of plane and space trusses.

KEYWORDS binary genetic algorithm, continuous genetic algorithm, failure criteria, optimum truss design

1. INTRODUCTION

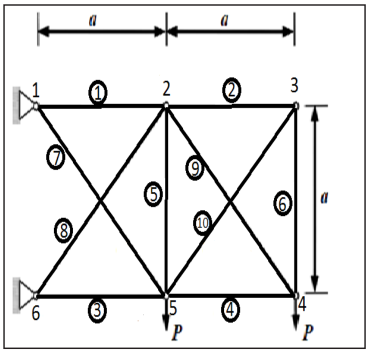
Galileo appears to be the first scientist who studied the optimization of structures, as we can see in his work on the bending strength of beams. Bernoulli, Lagrange, and Navier are just a few of the other great scientists who sought the "best" shapes for structural elements to satisfy the given strength requirements. As time passed, this discipline evolved and became an engineering area known as Structural Optimization, which seeks to determine the most economical geometrical shapes satisfying the constraints (e.g. stresses and deflections) imposed on the design. Traditionally, the design of a certain structure has depended on the experience of an engineer. Consequently, designed structures have often been suboptimal Steel truss structures are broadly used in real-world applications and a continuing motivation for research in optimal structural design exists. This observation is mainly due to the limited material and energy resources. The configuration optimization of steel trusses can provide a remarkable reduction in the weight and cost as a direct result. The problem involves determining the joints coordinates and members cross-sectional areas and lengths.

We focus on the use of genetic algorithms to optimize the design of plane and space trusses. The technique considers a discrete search space, yielding more realistic results than linear programming methods. Though some structural optimization techniques can deal with discrete search spaces, they suffer an inherent lack of generality and therefore can't be readily extended to other kinds of structures. The genetic algorithm (GA), for its part, is problem independent. The code developed for this work using finite element method. Finally, the GA has performance comparable to existing techniques.

2.Problem definition

The problems below are used to show the efficiency of genetic algorithms in the optimization of trusses. The algorithm are coded in Matlab, using the genetic algorithm. Standard benchmark problems were chosen.

Weight optimization of a 10 – Bars plane truss The geometry of 10-bar plane truss structure is show in figure . whose solution we illustrate, Joints may move only horizontally and vertically. The problem input data and constraints' limits are given as follows:



Dimensions
a = 9140 mm

P = 445374 N

E = 6.89e+4 mm^2

Areas A1 = A3 = 19700 mm^2
A2 = A4 = 8790 mm^2

A5 = A6 = 64.5 mm^2

A7 = A8 = 12500 mm^2

A9 = A10=12400 mm^2

σ =±1.72×108 N/m2 as the allowable stress for all members,

d =±5.08×10–2 m as the displacement limit of each joint in the vertical direction.

The truss loading condition is considered as follows:
P_{4y} =P_{5y} = -4.45E5 N

The problem in the question is solved by proposed BGA approach. The obtained optimal solution, outlined in table 1

This solution meets all design criteria, the structure weight associated with solution is 2542.93 Kg.

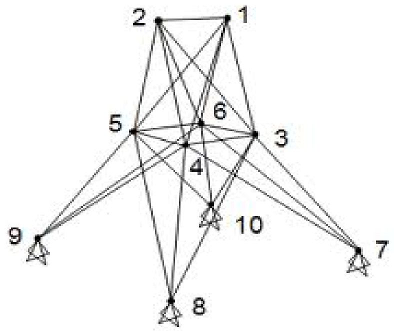
Table.1 Optimal solution for 10 bar truss

Member	Cross-section (cm^2)	Member	Cross-section (cm^2)
1	72.47	6	94.43
2	67.53	7	96.63
3	97.72	8	109.25
4	56	9	14.28
5	62.04	10	80.71

Table.2 compares the solution obtained with those associated with some other existing methods. References associated with others solutions are cited in table.

Name	Method	weight
Cai and thireu, 1993	IPFM	2490.72
Rajeev and krishnamoorthy,1992	GA	2,721.13
Coello,1994	GA	2,534.00
Rodrigo pruenca de souza,jun Sergio ono fonseca2	GA	2,351.90
Haftka	SLP	3,400.78
Rodrigo pruenca de souza1, jun Sergio ono fonseca2	SLP	3326.77158
Turkkan	Floating point GA	2490.99
Kripka	Simulated aneealing	2490.74
Tong, W.H, and liu	OP	2490.99
Farzin AMINAFAR1, farrokh AMINAFAR2,*,Daryoush NAZARPOUR3	AGA	2260
Present Work	GA	2542.93

THE 25-BAR TRUSS
The structure of the 25-bar problem is illustrated in below figure. The material properties including the design criteria are



Weight density = 2.77*10^3 kg/m^3

Youngs modulus = 6.89*10^10 N/m^2

Allowable stress = 2.76*10^8 N/m^2

Displacement = 8.89*10^-3 m limit of each joint

The truss loading condition is considered as follows:
P1x = 4.45*10^6 N

P1y = -4.45*10^7 N

P1z = -4.45*10^7 N

P2 y=- 4.45*10^7 N

P2z=- 4.45*10^7 N

P3x= 2.225*10^6 N

P6x = 4.45*10^6 N

Cross-sectional areas of members are to be adopted to be among the numbers in the range of 100 cm2 to 160 cm2.

Variable groups in 25 bar-truss.

Variable group	Members	Variable group	Members
1	1-2	5	3-4,5-6
2	1-4,2-3,1-5,2-6	6	3-10,6-7,5-8,4-9
3	2-4,2-5,1-6,1-3	7	4-7,3-8,5-10,6-9
4	4-5,3-6	8	6-10,3-7,4-8,5-9

The problem in the question is solved by proposed BGA approach. The obtained optimal solution, outlined in table 1

This solution meets all design criteria, the structure weight associated with solution is 2542.93 Kg.

Table.1 Optimal solution for 25 bar-truss

Variable group	Cross-section (cm^2)	Variable group	Cross-section (cm^2)
1	13.05	6	11
2	15.29	7	7.76
3	15.76	8	3.35
4	15.64	9	10.11

Table.2 compares the solution obtained with those associated with some other existing methods. References associated with others solutions are cited in table.

Name	Method	Weight(kg)
Hafkta	SLP	273.53
Rodrigo pruenca de souza,jun Sergio Ono fonseca2	SLP	226.2489
Rizz	GA	247.28
Rajeev and Krishnamoorthy	GA	247.66
Duan	GA	220.78
Wu and Chow	GA	274.87
Present work	GA	292.94

Conclusions

The GA seems to be a very good choice for discrete structural optimization, because of its generality and its ability to deal directly with discrete search spaces. Furthermore, the GA operates with several partial solutions simultaneously, in contrast with the traditional sequential search of the other methods. Our results show how well they perform even when compared with methods that use continuous search spaces, and are not portable and extremely complex. This does mean, however, that a program that uses this technique will fully replace human engineers in the design process, because a lot of common sense is still required in such a complex task. Nevertheless, GAs should be expected to play a main role in the structural design software of the future.

REFERENCES

1. Haftka R T and Gürdal Z. Elements of structural optimization. 3rd rev. Netherlands: Kluwer Academic Publishers, 1991 | 2. Cai, J. B., and Thiereut, G., 1993, "Discrete Optimization of Structures Using an Improved Penalty Function Method", Engineering Optimization, Vol. 21, No. 4, pp.293-306. | 3. Rajeev.S and Krishnamoorthy,C. S., 1992, "Discrete Optimization of Structures Using Genetic Algorithms", Journal of Structural Engineering, ASCE, Vol. 118, No. 5, pp. 1233-1250. | 4. Duan M. Z., 1986, "An Improved Templeman's Algorithm for the Optimum Design of Trusses with Discrete Member Sizes", Engineering Optimization, Vol. 9, No.4, pp. 303-312. | 5. Wu S-J, Chow P-T. Integrated discrete and configuration optimization of trusses using genetic algorithms. Comput Struct, 1995; 55(4):695–702. | 6. Rodrigo Pruença de Souza, Jun Sergio Ono Fonseca.Optimum Truss Design under Failure Constraints Combining Continuous and Integer Programming, Rio de Janeiro, Brazil, 01 - 05 June 2008. | 7. Farzin AMINIFAR, Farrokh AMINIFAR, Daryoush NAZARPOUR, Optimal design of truss structures via an augmented genetic algorithm, Turkish J Eng Env Sci (2013) 37: 56 – 68. | 8. Coello Coello C (1999a) A comprehensive survey of evolutionary- based multiobjective optimization techniques. Knowl Inf Syst 1(3):129–156 | 9. Tong, W.H. and Liu, G.R. An Optimization Procedure for Truss Structures With Discrete Design Variables and Dynamic Constraints, Computers & Structures, Vol. 29, pp. 155-162, 2001. | 10. Kripka, M. Discrete Optimization of Trusses by Simulated Aneealing, Journal of the Brazilian Society of Mechanical Sciences and Engineering, Vol. XXVI, No. 2, April-June, 2004. |